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MAR 1963 SPECIFICATION

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COMPLETE SPECIFICATION

NO DRAWINGS

Steel Alloy Composition

We, NORTH AMERICAN AVIATION, INC., a corporation organised and existing under the laws of the State of Delaware, United States of America, of International Airport, City of Los Angeles, State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a high temperature alloy. More particularly, this invention relates to a high temperature steel alloy with low thermal coefficient of expansion, high thermal conductivity, and good high temperature mechanical properties.

Austenitic stainless steels are well known in the art. An example of a stainless steel is AISI type No. 304 which contains from 18% to 20% chromium and 8% to 11% nickel with 2% max. of manganese. It has a low carbon content and has many uses. However, it has some drawbacks, one of which is its relatively high cost because of the high chromium and nickel content. Also, its thermal coefficient of expansion is a little high for certain applications while its thermal conductivity is too low. On the other hand, ferritic steels have low coefficients of expansion and a high thermal conductivity as well as low cost, but they are weak at elevated temperatures. Consequently, it would be advantageous to obtain a ferritic alloy which would combine the conductivity and expansion properties of ferritic steels with the excellent strength properties of austenitic steels for use at high temperatures. For such application, high thermal conductivity, low thermal coefficient of expansion, and therefore, low thermal stresses are important.

It is, therefore, an object of this invention to provide a steel alloy having high creep and stress rupture properties at elevated temperatures.

It is also an object of this invention to provide a steel alloy having a high corrosion resistance in molten metal service.

Another object of this invention is to provide a steel alloy having adequate strength and ductility in the heat-affected zones of units formed by welding together assemblies of pieces without costly post-weld heat treatments.

Another object of this invention is to provide a ferritic steel alloy having high temperature properties equal to or surpassing those of the austenitic steels.

Still another object is to provide a steel alloy which is obtainable at a much lower cost than stainless steel.

It is also an object to provide a steel alloy which has a low coefficient of expansion, a high thermal conductivity, and a high resistance to thermal stresses at elevated temperatures.

Still other objects of this invention will become apparent from the discussion which follows

The above and other objects of this invention are obtained by providing a steel alloy having improved high temperature properties containing from 0.4% to 7.5% chromium, from 0.4% to 4% molybdenum, from 0.05% to 0.4% carbon, from 0.1% to 1.5% manganese, from 0.1% to 1% niobium, from 0% to 1.4% titanium, from 0% to 4% nickel, and the remainder essentially iron. In this specification, the phrase "the remainder essentially iron" is intended to mean that the alloy may contain 0.1% (max.) boron, 0.02% (max.) nitrogen, 0.2% (max.) aluminium, 1.5% (max.) silicon, 0.03% (max.) phosphorus, and 0.03%

[Price 4s. 6d.]

The chemical analysis of the steel alloy of this invention given in Tables II and III as Fe+2.25 Cr+1 Mo+0.4 Ti+0.4 Nb is that given for heat No. 27 in Table I, supra. It will be noticed from Table III that the alloy of this invention requires from 6.7% to 53% higher stress to rupture in the same time as that required for the rupture of 304 stainless steel, and from 78% to 152% higher stress than required for the rupture of ferritic steel containing 2.25 weight % chromium and 1 weight % molybdenum. That is, by adding a small amount of niobium and titanium, the composition of the steel is improved with respect to stress to rupture by 152%. From Table II it is seen that the offset yield strength of the niobium- containing alloy of this invention is 124% higher than that of 2.25% chromium and 1% molybdenum ferritic steel and 150% higher than that of 304 stainless at room temperature; 147% higher than that of ferritic steel and 378% higher than at of stainless steel at 1050°F (565°C); and 206% higher than ferritic steel and 366% higher than stainless steel at 1200°F (650°C). It is also seen that the ultimate tensile strength of the niobium-containing steel is 35% higher than that of ferritic steel and 26% higher than that of stainless steel at room temperature; 41% higher than that of ferritic steel and 29% higher than that of stainless steel at 1050°F; and 82% higher than that of ferritic steel and 25% higher than that of stainless steel at 1200°F. From Table III it is also noted that the minimum creep rate of the niobium-containing steel of this invention is from 2 to 10 times lower than for ferritic steel and from 5 to 10 times lower than that of the 304 stainless steel. Thus components manufactured from the steel alloys of this invention will deform only at very slow rates when in highly stressed service at temperatures up to at least 1100°F.

The steel alloy specimens of this invention used for the tests given in Tables II and III were 4 inches long with a 1.5 inch gauge length and a gauge diameter of 0.375 inch. The specimen steel alloys of this invention described in the Examples and in Table I, like the speciment used to illustrate the improvement in the properties listed in Tables II and III, all have properties which are an improvement over the ferritic and stainless steel compositions.

WHAT WE CLAIM IS:—

1. An alloy having improved high temperature properties containing
from 0.4% to 7.5% chromium
from 0.4% to 4% molybdenum
from 0.05% to 0.4% carbon
from 0.1% to 1.5% manganese
from 0.1% to 1% niobium
from 0% to 1.4% titanium
from 0% to 4% nickel
and the remainder essentially iron.

2. An alloy according to claim 1, containing from 1.5% to 7.5% chromium and from 0.08% to 0.3% carbon.

3. An alloy according to claim 1 or 2, which does not contain any nickel.

4. An alloy according to claim 1 or 2, which contains from 0.1% to 4% nickel.

5. An alloy according to claim 1, which contains 2.25% chromium, 1% molybdenum, 0.4% titanium, and 0.4% niobium.

6. An alloy according to any of claims 1 to 5, which does not contain any titanium.

7. An alloy according to any of claims 1 to 5, which contains from 0.2% to 1.5% niobium and titanium and wherein the amount of niobium is from 0.1% to 1%.

8. An alloy according to claim 1, containing
from 0.4% to 7.5% chromium
from 0.4% to 4.0% molybdenum
from 0.05% to 0.4% carbon
from 0.1% to 1.5% manganese
from 0.1% to 1.0% niobium
from 0.1% to 1.4% titanium
and the remainder essentially iron.

9. An alloy according to claim 1, containing
from 2.0% to less than 4.0% chromium
from 1.0% to 2.0% molybdenum
from 0.05% to 0.4% carbon
from 0.1% to 1.5% manganese
from 0.1% to 1.0% niobium
from 0.1% to 1.4% titanium
and the remainder essentially iron.

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